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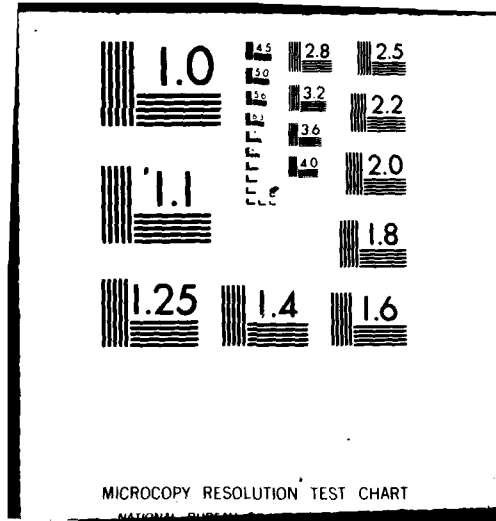
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TECHNICAL MEMORANDUM

WSRL-0256-TM

A COMPACT RANGE FOR INTERNAL BALLISTIC ASSESSMENT OF
SMALL ARMS AMMUNITION

K.H.J. ADAMS

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A COMPACT RANGE FOR INTERNAL BALLISTIC ASSESSMENT OF
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K.H.J. Adams

S U M M A R Y

A compact ballistic range has been set up for measuring action time, in-barrel pressures and muzzle velocity for small calibre ammunition. Inexpensive commercial sky screens have been modified to provide a very accurate velocity meter.



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1. INTRODUCTION

A ballistic range (Range D) is being established within WSRL for the research and development of propellants which are used in rounds up to 40 mm calibre. Propellants for larger calibre weapons will need to be proven on a range outside the laboratory area.

It was evident that a compact range for assessing small arms ammunition (up to 9 mm) was also needed to cater for the extensive firing programmes proposed. This ballistic range has now been established. It embodies a miniature and very accurate muzzle velocity meter which has been developed from inexpensive commercially available electronic chronometers, and a digital data acquisition system for in-barrel pressure measurement. The latter system initially stores pressure data on tape (cassette) and thence via a secondary tape it can be analysed in the DRCS IBM 370 computer. This system, it is considered, might have further application where trials data are recorded at ranges outside the Laboratory area. More usually the data are processed in situ in a small dedicated desk top computer and the results plotted locally.

2. DESCRIPTION OF RANGE FACILITY

2.1 Summary

The small arms Ballistic Range comprises four adjacent rooms (figure 1) which house a projectile catcher, velocity meters, a gun mount and instrumentation respectively.

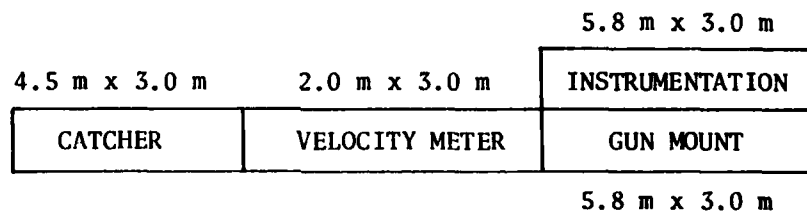


Figure 1. Layout of ballistic range

2.2 Projectile catcher

The catcher comprises a simple wooden box (1.25 m x 0.65 m x 0.6 m). The first 0.6 m is filled with sawdust and the remainder with gravel. A 25 mm steel plate is mounted at the far end of the catcher at an inclination of 45° to the line of fire. The whole unit is contained in a concrete walled room.

2.3 Velocity meters

The velocity meters embody Oehler type II sky screens which have been modified to improve accuracy and artificial illumination has been provided. The Oehler sky screen comprises a silicon detector diode contained in a housing which collimates light onto the diode by means of two slits as shown in figure 2.

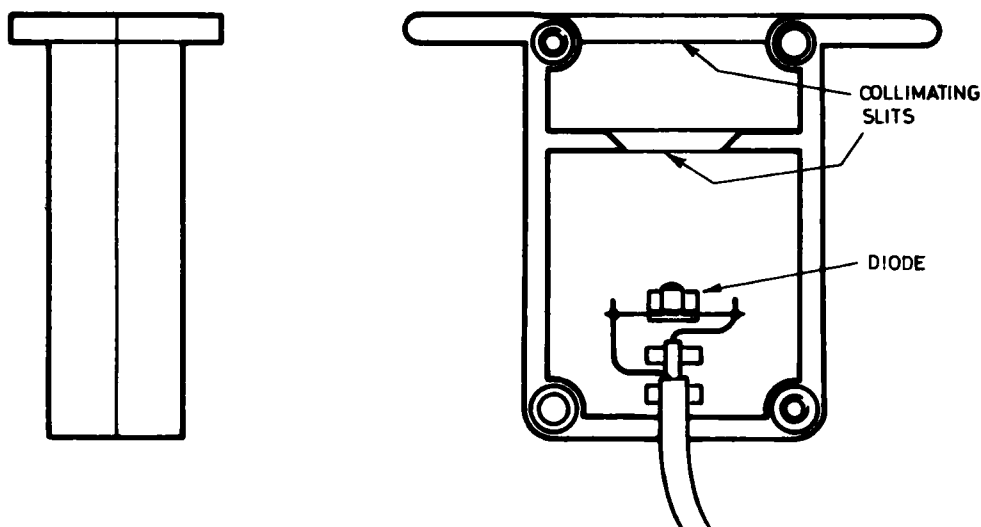


Figure 2. Schematic of commercial sky screen (actual size)

The diode is reverse biased and conducts only when illuminated. A projectile passing above the slit (within an angle of approximately 40° subtended symmetrically at the diode) reduces the radiance falling on it ephemerally and hence the current. The small current change is amplified and starts a one megahertz clock contained in an associated chronometer; a second sky screen at a known distance from the first stops the clock. The time of flight between the two screens is thus timed and the velocity computed.

Three pairs of screens have been employed to provide redundancy and a cross check on accuracy. They are mounted on a two metre long optical bench and each pair has been set at 1.5 m apart.

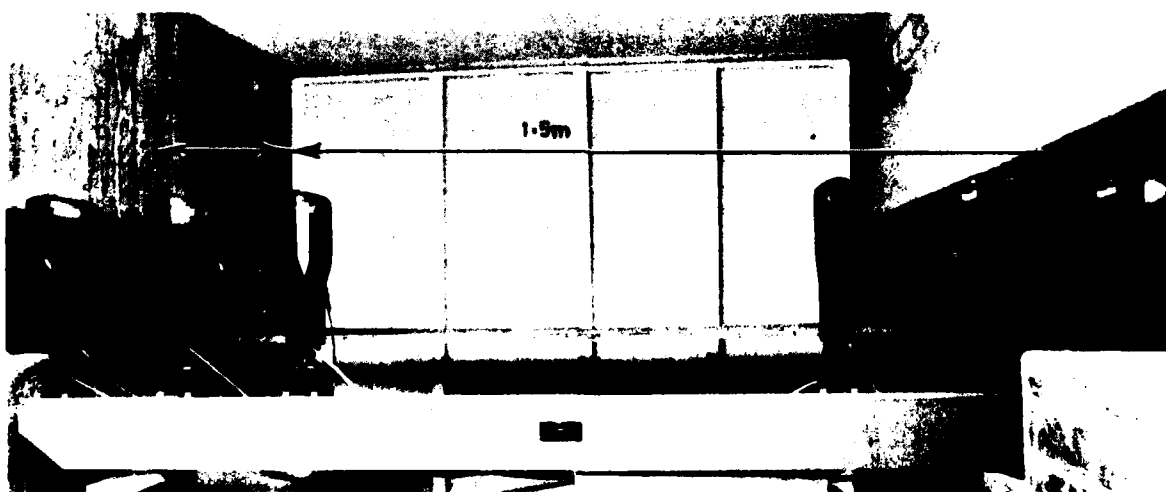


Figure 3. Arrangement of screens on an optical beam

Artificial illumination is achieved indoors by mounting a 500 W quartz iodine strip light above each screen. The accuracy of measurement of muzzle velocity by this method depends on the accuracy with which the screens can be positioned relative to one another and the precision with which they sense the passage of the bullet above them. Each screen should trigger the clock when the projectile is in precisely the same position relative to it. The following steps have been taken to optimise the accuracy.

(a) The diodes in the screens were preselected to have near identical electrical and optical characteristics.

(b) The radiation falling onto each detector diode was collimated precisely by placing a cylindrical reflector behind the quartz lamp and a convex lens on the front face of the screen (figure 4).

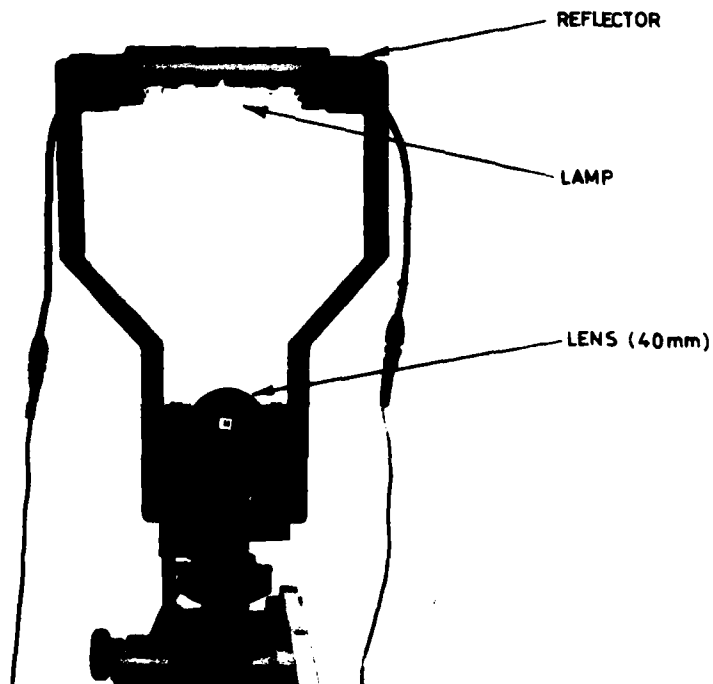


Figure 4. Construction of modified screen

(c) The intensity of illumination was adjusted to produce the same current in each diode at the maximum sensitivity.

(d) Accurate separation of the screens to ± 0.1 mm was achieved by mounting on the optical bench.

These four modifications have improved the accuracy from about 1% to better than $\pm 0.05\%$. The accuracy was judged by comparing the differences between three pairs of screens. Typical results are shown in Table 1.

TABLE 1. TYPICAL RESULTS FROM THREE VELOCITY METERS (A, B AND C)

Firing No.	Velocity (m/s)		
	C	B	A
1	839.8	839.3	839.3
2	848.8	849.3	848.4
3	867.0	867.0	866.5
4	846.5	846.9	846.0
5	850.3	849.8	849.8
6	859.5	859.1	859.1
7	852.7	853.2	852.7
8	855.6	855.6	855.1
9	873.6	873.1	873.6
10	866.0	865.5	865.5

Some spurious triggering of individual screens was observed. Much of this was due to electrical pickup in the unshielded leads from the chronometers to the screens. Replacing the leads with triaxial cable eliminated most of the problem.

2.4 Gun firing platform

All barrels are mounted on a locally designed platform shown in figure 5. The proof barrels are dimensioned to fit into the V blocks on this platform which also allows the use and measurement of controlled recoil. The firing mechanism comprises a conventional bolt action (P14 Rifle) and trigger.

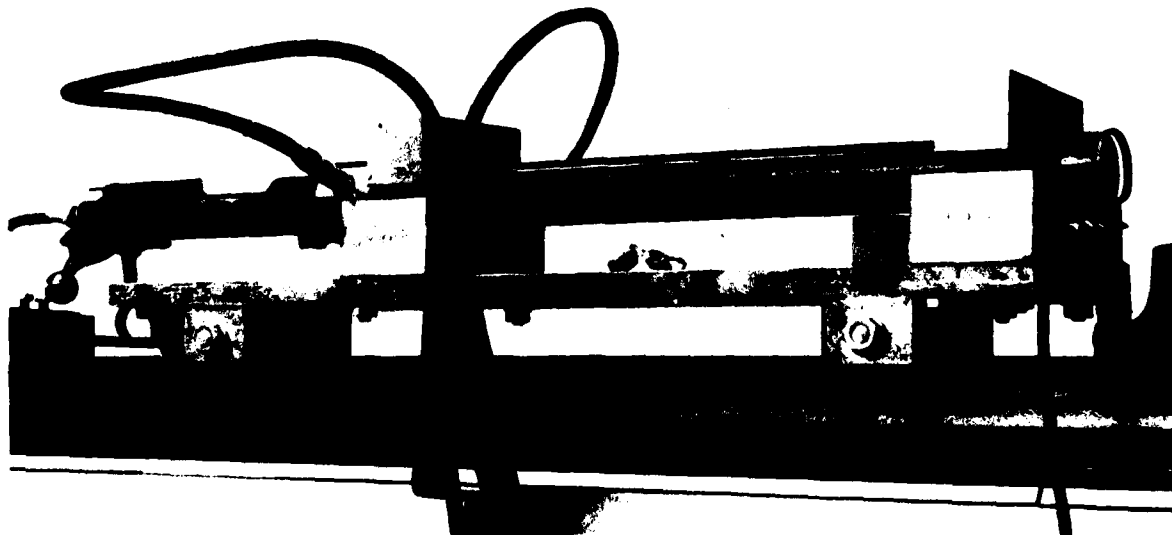


Figure 5. Universal platform for small calibres

Figure 5 shows a 5.56 mm proof barrel in place with two Kistler type 6203 quartz pressure gauges mounted diametrically opposite one another at the cartridge case mouth. The gauges are calibrated to 500 MPa. Currently up to four pressure transducers can be installed in any arrangement of positions on a barrel and the pressure versus time transient recorded. Action time is also measured and is defined as that time interval between primer strike and muzzle exit. The former is measured by insulating the firing pin in the bolt from the remainder of the equipment. The instant when the firing pin strikes the primer can then be detected electrically and the event recorded. Muzzle exit time is recorded by detecting the ionized gases which accompany the bullet when it emerges from the barrel. This is achieved by placing, at the muzzle, an insulated copper ring. It becomes negatively charged by the gases to a preset potential to operate a Schmidt trigger.

2.5 Instrumentation

The electronic equipment to record and process the outputs from the velocity screens, the pressure gauges and the action time circuits is housed in an adjacent room (figure 6).

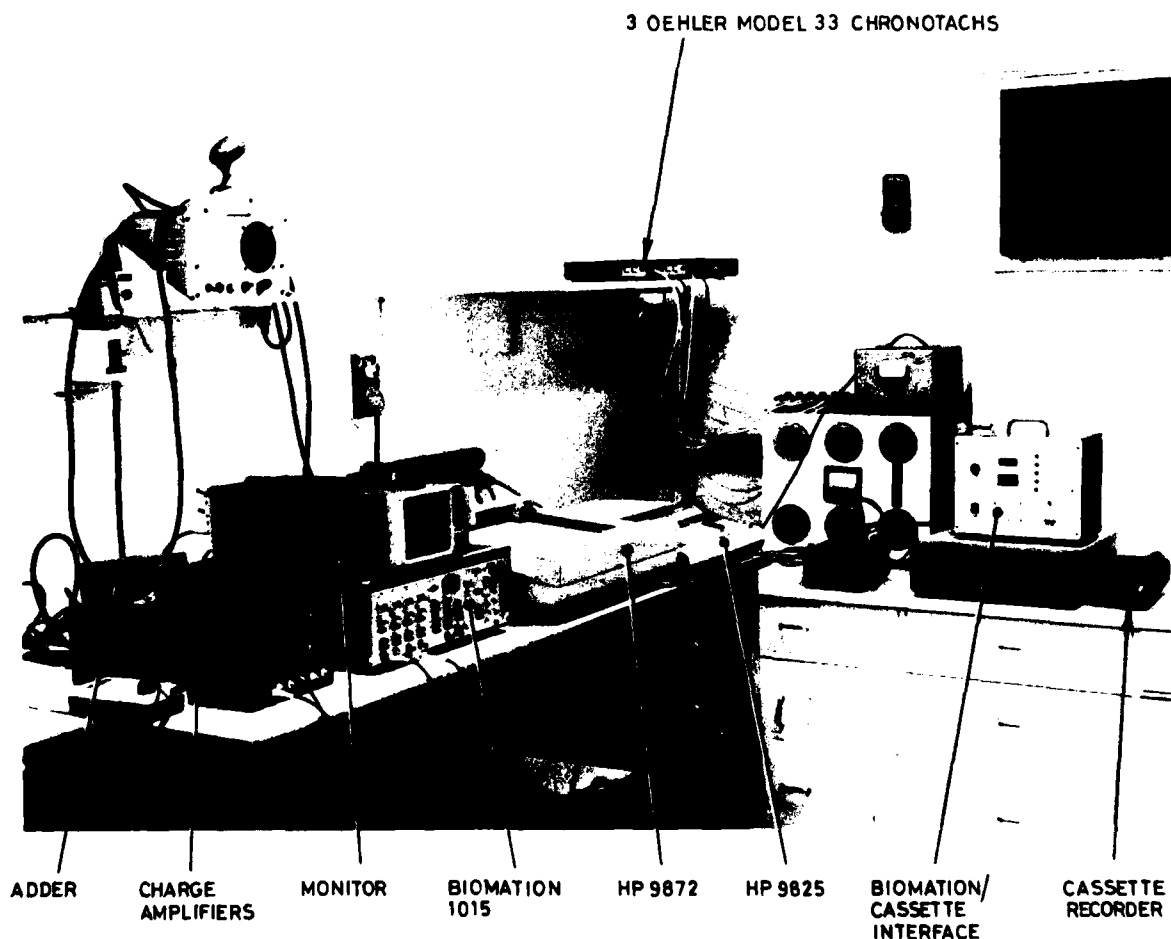
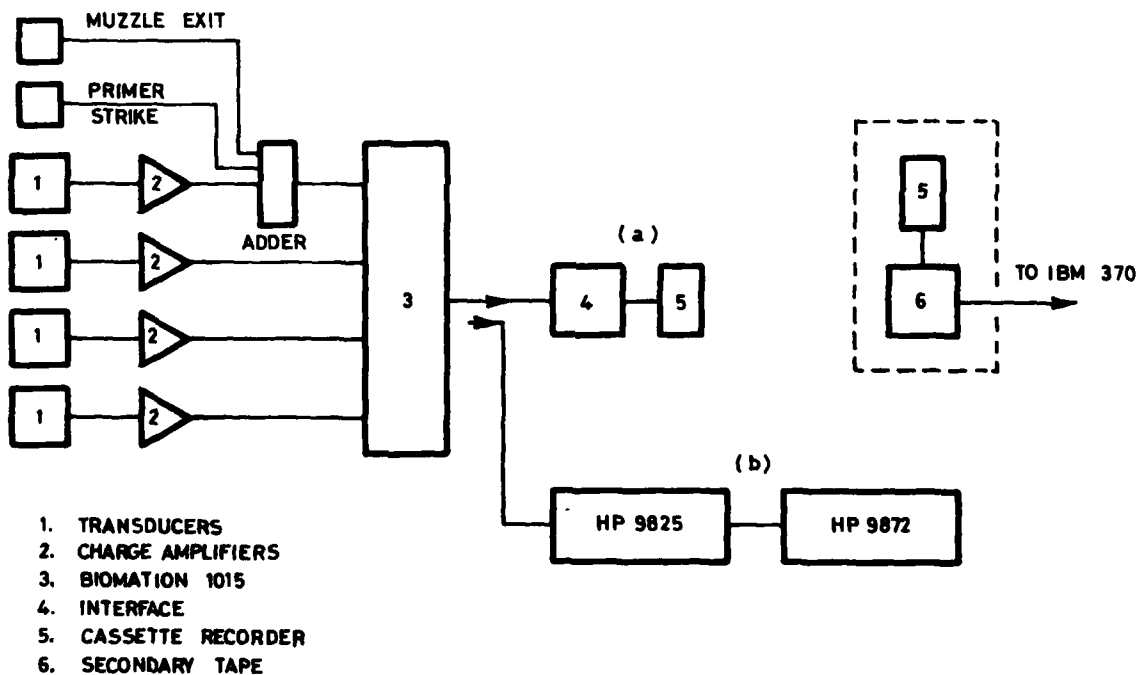


Figure 6. Instrumentation room

The three chronometers associated with the velocity screens are housed in this bay. They embody a 1 MHz clock and microprocessor. Each value of velocity is stored in the microprocessor memory. Statistical data are then calculated from a batch of firings.

Signals from up to four pressure gauges are preconditioned in charge amplifiers (Sundstrand, PCB or Meclec) and then stored in a digital transient recorder (Biomation type 1015). The digitised pressure data are then transferred to magnetic tape via a locally designed interface and thence via a secondary tape to the DRCS IBM 370/168 computer as a data set. This data can then be accessed by any range user at any computer terminal in DRCS for further analysis.

However, data are usually transferred to the memory of an HP9825 desk top computer which is housed in the instrumentation room and processed in situ. The pressure time curve is plotted on an HP9872 plotter. A schematic of these two alternatives is shown in figure 7.



(a) IBM 370

(b) HP9825

Figure 7. Schematic arrangement of instrumentation

Typical plots from both systems are shown in figure 8(a) and (b).

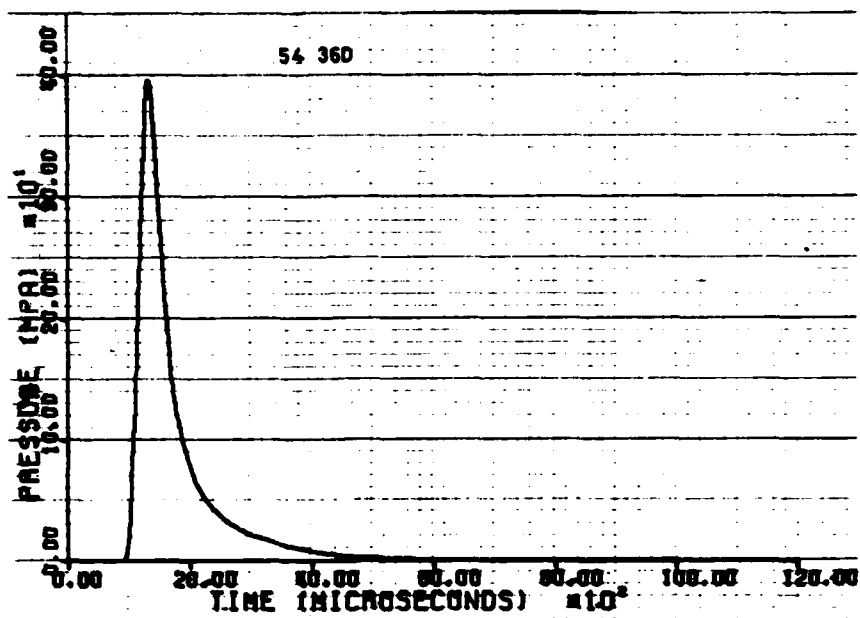


Figure 8(a). Pressure time plot from IBM 370

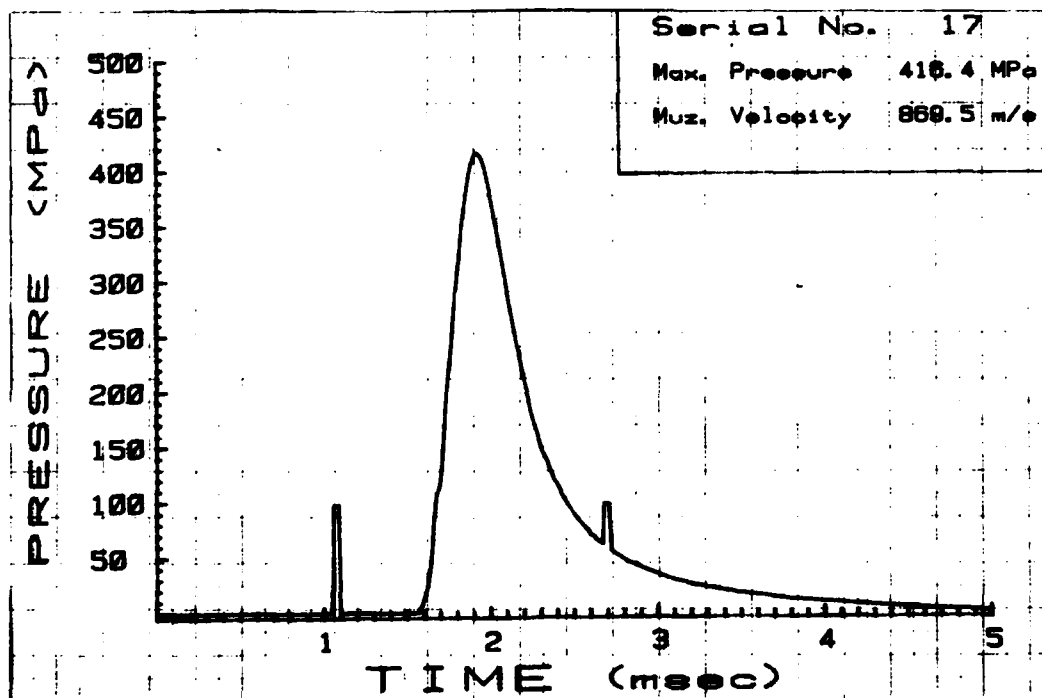


Figure 8(b). Pressure time plot from HP9825 onto an HP9872

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